

USE OF CORTICAL STRUCTURAL HOMOLOGOUS BONE GRAFT IN FEMORAL RECONSTRUCTIVE SURGERY

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ABSTRACT

Objective: To perform a clinical and radiographic assessment of patients undergoing surgical treatment using a cortical structural homologous bone graft for femoral reconstruction following mechanical failure of total hip arthroplasty and periprosthetic fractures. **Methods:** A retrospective study was conducted on 27 patients who underwent surgical treatment for femoral reconstruction following mechanical failure of total hip arthroplasty (12 cases) and periprosthetic fractures (15 cases), using a cortical structural homologous bone graft and cemented implants, between June 1999 and February 2008. Of these, 21 fulfilled all the criteria required for this study. The patients underwent pre and postoperative clinical assessments using the Harris Hip Score. Preoperative, immediate postoperative and late postoperative radiographs were also evaluated, with comparisons of fracture consolidation, radiographic signs of graft consolidation, changes to the bone stock and femoral bone

quality, and femoral alignment. **Results:** Nine patients (42.9%) underwent femoral reconstruction following mechanical failure of total hip arthroplasty and 12 cases (57.1%) underwent femoral reconstruction following periprosthetic fracture. Regarding the postoperative clinical classification, the results were considered satisfactory in 85.7% of the cases and unsatisfactory in 14.3%. Radiographic signs of graft consolidation were seen in all cases. There was an increase in bone stock in 90.5% of the hip reconstructions, as measured by the cortical index. Furthermore, the changes to femoral bone quality were considered good in 66.7% of the cases. **Conclusion:** The use of cortical structural homologous bone grafts for both femoral reconstructive surgery on total hip arthroplasty and periprosthetic fractures is a good treatment option for selected cases, enabling satisfactory clinical and radiographic results.

Keywords – Femoral Fractures; Arthroplasty, hip/methods; Hip Prosthesis; Bone Transplantation

INTRODUCTION

Loss of femoral bone stock is a serious complication that can occur both as a result of periprosthetic fractures and in cases of arthroplasty failure^(1,2).

The incidence of periprosthetic fractures, which occur in 1% to 6% of hip arthroplasty cases, has increased significantly over the last decade because of increased longevity among patients^(3,4). These fractures occur more

commonly after primary arthroplasty, as a result from cortical damage during the operation. In turn, fractures that occur during or after revision arthroplasty are related to loss of femoral bone stock^(5,6). In these cases, the treatment is based on the patient's clinical condition, the location of the fracture, the stability of the femoral component and the bone quality of the proximal third of the femur⁽⁷⁾.

Many surgical techniques and implants have been de-

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veloped for femoral reconstruction following failure of hip arthroplasty, which shows the complexity of treating it^(8,9). These cases may evolve with extensive osteolytic lesions, bone discontinuity or implant rupture^(10,11).

The aim of femoral reconstructions and fixation of periprosthetic fractures is to achieve a stable implant, with maintenance or replacement of the bone stock^(12,13). The treatment options include cemented or non-cemented nails, which may be used together with autologous or homologous bone grafts^(14,15). The use of structural homologous bone grafts enables high fracture consolidation rates and increased femoral bone stock^(3,16).

The objective of the present study was to assess the clinical and radiographic results from using cortical structural homologous bone grafts in femoral reconstruction surgery following failure of total hip arthroplasty and periprosthetic fractures.

METHODS

The present study was approved by the Research Ethics Committee of the Orthopedics Hospital of Passo Fundo.

A retrospective study was conducted on 27 patients who underwent surgical treatment for femoral reconstruction following failure of total hip arthroplasty (12 cases) or periprosthetic fractures (15 cases), using cortical structural homologous bone grafts (non-irradiated) and cemented implants, between June 1999 and February 2008. All the operations were carried out by the same medical team, at the Hip Surgery Service of the Orthopedics Hospital of Passo Fundo, RS.

The patients included in the study had had one or more previous arthroplasty procedures and presented loss of femoral bone stock following aseptic failure of the arthroplasty or periprosthetic fractures. They underwent surgical treatment that made use of cortical structural homologous grafts, with a minimum follow-up of one year. The exclusion criteria were loss from follow-up (four cases) and incomplete radiographic examinations (two cases).

In accordance with the criteria established, 21 patients were included in this study, of whom 17 were female (81%) and four were male (19%). The right sided was more affected (13 femurs).

The mean age of the patients at the time of the surgery was 62 years, with a range from 35 to 81 years. The mean length of follow-up was two years and eleven months, with a minimum of one year and maximum of

seven years and three months.

Preoperative and postoperative clinical assessments were performed on all the patients, with the aim of classifying them using the Harris Hip Score⁽¹⁷⁾. The postoperative results were considered poor if the patients' scores were lower than 70; reasonable, between 70 and 79; good, between 80 and 89; and excellent, between 90 and 100. Excellent and good clinical results were classified as satisfactory. Reasonable and poor results were considered to be unsatisfactory⁽¹⁸⁾.

The cortical structural homologous bone graft material ("bone ruler") that was used came from the musculoskeletal tissue bank of Hospital São Vicente de Paulo, in Passo Fundo. This material had not been irradiated and had been processed from femoral and tibial diaphysis segments from donors. The material had standard dimensions of 2.5 cm in width by 15 cm in length, and it was adjusted during the operation in accordance with the surgical requirements.

In 19 patients (90.5% of the cases), the structural homologous bone graft was used together with cerclage wiring as a method for stabilizing the femoral reconstruction. Of these, in nine cases (42.9%), the graft was seen to be present on the lateral and anterior faces of the femur, and in ten cases (47.6%), only on the lateral face. In the remaining two patients (9.5% of the cases), a structural graft was used on the anterior face of the femur, together with cerclage wiring and fixation of the fracture using a plate and screws.

The femoral bone defects were classified in accordance with the D'Antonio system, as adopted by the American Academy of Orthopaedic Surgeons (AAOS)⁽¹⁹⁾. The periprosthetic fractures were assessed in accordance with the Vancouver system apud Masri et al⁽²⁰⁾.

For all the patients selected for this study, preoperative and immediate and late postoperative radiographs were available. These were compared with regard to fracture consolidation; radiographic signs of consolidation of the cortical structural graft; changes to the femoral bone stock and bone quality; and femoral alignment.

Radiographic analysis

The radiographic analysis on the cortical structural homologous grafts was performed by two observers separately, using the same pachymeter and ruler, with the aim of avoiding intra-observer errors. Radiographs of the pelvis and femur in anteroposterior and lateral views were analyzed in relation to fracture consolidation

(in the cases of periprosthetic fractures), radiographic signs of graft consolidation, changes to femoral bone stock and bone quality, and femoral alignment (Figures 1 and 2).

Consolidation of the periprosthetic fractures was characterized by the presence of continuity of radiographic density and formation of bone callus over the fracture focus⁽³⁾.

The radiographic signs of graft consolidation were determined in accordance with the criteria of Emerson *et al*⁽¹³⁾, in five categories: 1) reabsorption of the proximal and distal edges of the structural graft (corresponding to softening of the outlines of the cortical structural graft); 2) presence of bone erosion (indicating neovascularization of the graft), 3) partial bone bridges; 4) complete bone bridges; 5) obliteration of the graft-host bone interface (thus indicating revascularization of the graft); 6) reabsorption (with diminution of the thickness of the

structural bone graft to varying degrees, corresponding to remodeling of the femur). The graft may present characteristics of more than one category simultaneously, and these authors emphasized that formation of a partial bone bridge greater than 50% between the cortical structural homologous graft and the host bone, or formation of a complete bridge, were absolute criteria for graft consolidation.

Changes to the femoral bone stock were evaluated in accordance with the criteria of Haddad *et al*⁽³⁾, by means of the cortical index, which corresponded to the relationship between the diameters of the femur and the medullary canal, measured one centimeter distally to the lesser trochanter, which serves to quantify the bone loss, as reflected in the femoral isthmus. This index was measured on radiographs in the anteroposterior and lateral views, before the operation and at a late postoperative time. This measurement could not be made in



Figure 1 – A) Preoperative radiograph on periprosthetic fracture; B) Radiograph produced during immediate postoperative period, showing fixation using cortical structural bone graft and cerclage wiring; C) Postoperative radiograph produced after one year and seven months of follow-up, showing consolidation of the fracture and bone graft.



Figure 2 – A) Preoperative radiograph on femoral revision; B) Radiograph produced during immediate postoperative period, showing the use of a cortical structural bone graft and cerclage wiring; C) Postoperative radiograph produced after three years and ten months of follow-up, showing consolidation of the bone graft.

two patients who were treated with surgical fixation of periprosthetic fractures using plates, because the image of the metal was superimposed on the image of the femoral cortical bone.

The quality of the femoral bone was classified as good or poor in accordance with Callaghan *et al*⁽²¹⁾, through comparison of radiographs produced before the operation and at a late postoperative time. The quality was considered poor when the femoral cortical bone thickness at the late postoperative time, measured 10 cm from the lesser trochanter, was 50% smaller than before the operation, or when it was 75% smaller, measured 5 cm from the lesser trochanter, or when both of the cortical bone measurements at any point below the lesser trochanter measured less than 4 mm.

Stabilization of the cortical structural homologous graft

The cortical structural homologous bone grafts were positioned on the lateral and/or anterior face of the femur, which was fixed by means of cerclage wiring and screws. The graft-host bone interface was filled with fragmented homologous bone graft material, with the aim of avoiding the formation of “dead space” that might allow fibrous tissue or cysts to form, which would create difficulties relating to consolidation of the structural graft (Figure 3).

Statistical analysis

Comparisons between the pre and postoperative radiographic measurements, in relation to changes to femoral bone stock and bone quality, were made using the nonparametric Wilcoxon signed-rank test, given that this was a sample with non-constant variance and coefficient of asymmetry. Findings were taken to be statisti-

cally significant when $p < 0.05$. The statistical data were calculated using the SPSS 15.0 package.

RESULTS

Out of the total number of patients evaluated, nine (42.9%) underwent surgical treatment for femoral reconstruction following failure of total hip arthroplasty and another 12 cases (57.1%) underwent surgical fixation of periprosthetic fractures, using cortical structural homologous bone grafts (Figure 4).

Preoperative clinical classification in accordance with the Harris Hip Score (17,18) was done only for nine patients. In the other 12 cases, this evaluation was not done because of the presence of periprosthetic fractures. Among the cases thus assessed, a mean of 30 points was obtained (range from 22 to 42 points). After the operation, the results were considered to be excellent in eight cases (38.1%), good in ten (47.6%), reasonable in two (9.5%) and poor in one (4.8%). Therefore, satisfactory clinical results were obtained in 85.7% of the cases. The

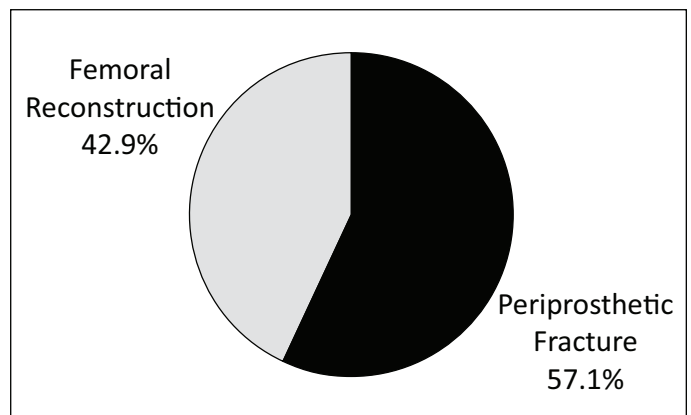


Figure 4 – Characterization of the patients regarding the surgical procedure that was carried out.

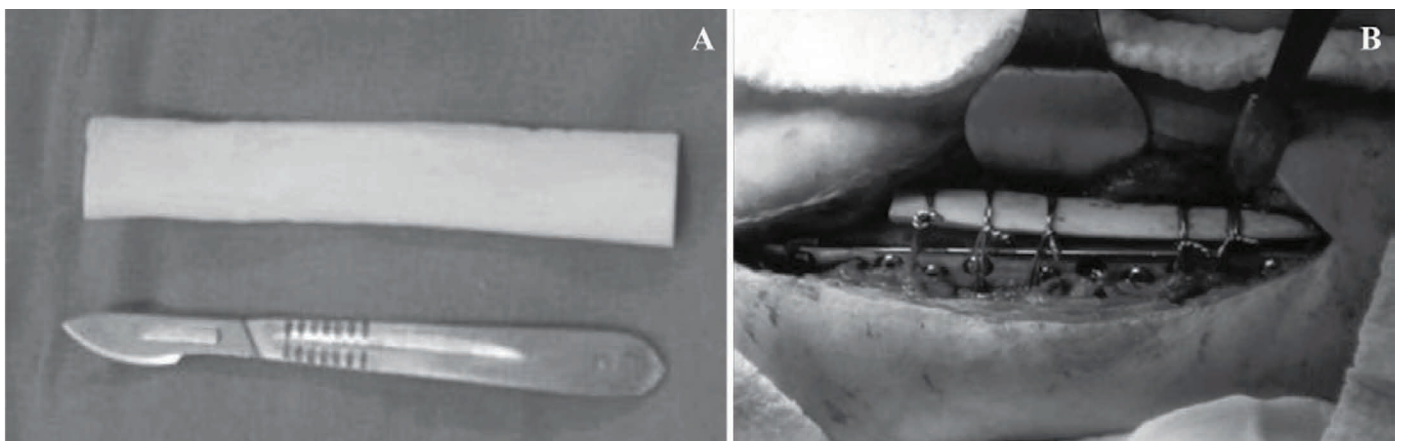


Figure 3 – A) Cortical structural homologous bone graft; B) During the operation, with fixation of the graft by means of cerclage.

mean score was 85 (range: 62 to 98 points) (Figure 5).

According to the D'Antonio classification, as adopted by the AAOS(19), five femoral defects (23.8%) were considered to be segmental (type I); two (9.5%) were cavitary (type II); two (9.5%) were of combined type (type III) and 12 (57.2%) presented a discontinuity (type IV). All the periprosthetic fractures were classified as bone defects of type IV (Figure 6).

With regard to the Vancouver classification apud Masri et al(20), for periprosthetic fractures, one case was

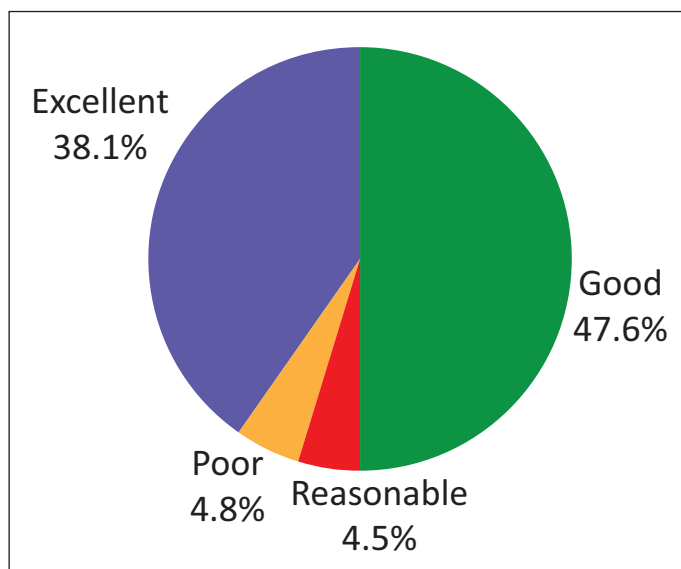


Figure 5 – Postoperative clinical classification according to the Harris Hip Score^(17,18).

considered to be B1 (8.3%); three cases, B2 (25.1%); four cases, B3 (33.3%); and four cases, C (33.3%). In all of these patients, consolidation of the fracture focus was achieved.

Radiographic signs of graft consolidation were seen

in all the patients. All the cases presented bone erosion. In five cases (23.8%), formation of a partial bridge covering more than 50% of the extent of the cortical structural graft was achieved. The other cases developed complete bridges. Obliteration of the graft-host bone interface was demonstrated in 17 cases (80.9%). Sixteen patients (76.2%) presented reabsorption of the edges to varying degrees, thus indicating that remodeling of the femur was occurring.

There was an increase in the bone stock in 90.5% of the cases (19 patients), according to the values in the cortical index proposed by Haddad et al⁽³⁾, which was corroborated by a statistically significant difference ($p = 0.001$) between the pre and postoperative radiographic measurements. The mean cortical index found after the operation was 1.79, with a range from 1.47 to 2.08. This measurement could not be made in two cases because of the presence of a metal plate.

The change to the femoral bone quality was classified as good in 66.7% of the cases (14 patients) and poor in the remainder. The relationship of bone quality improvement between the pre and operative measurements was statistically significant ($p = 0.005$ for 5cm and $p = 0.000$ for 10 cm).

There were three cases of non-anatomical femoral alignment (14.3%), presenting varus of 5° in two cases and 10° in one case. However, this abnormality of femoral alignment did not cause a functional deficit, since the postoperative Harris Hip Score^(17,18) was satisfactory.

With regard to complications, two patients (9.6% of the cases) presented an episode of dislocation of the implant. There were no cases of infection.

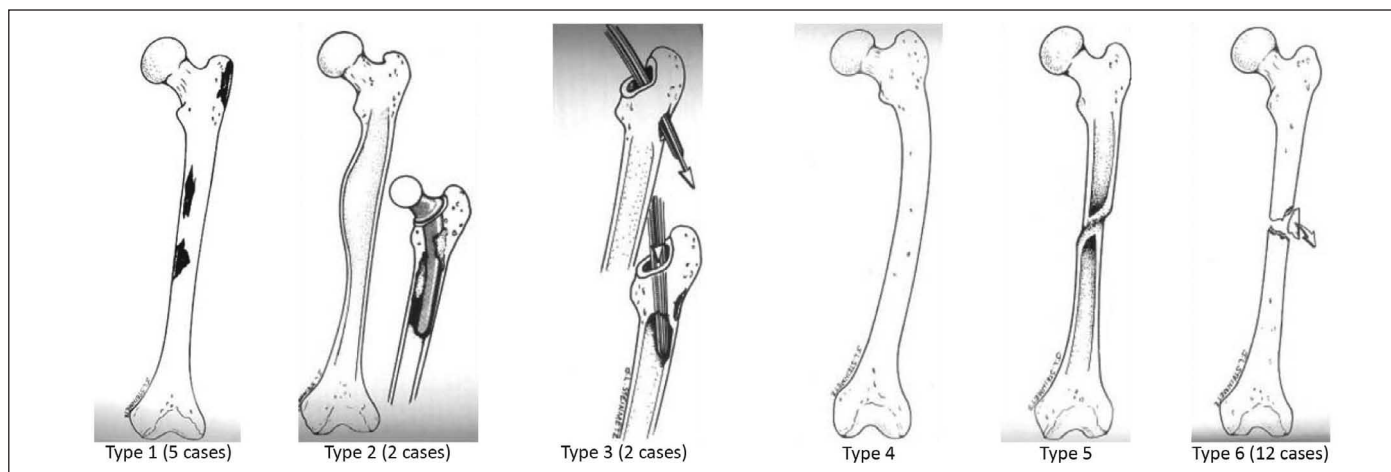


Figure 6 – AAOS classification of femoral defects, in accordance with D'Antonio et al⁽¹⁹⁾.

DISCUSSION

Cases of failure of hip arthroplasty and periprosthetic fractures frequently evolve with diminution of the femoral bone stock, thus making their treatment a challenge for hip surgeons^(1,2). A variety of treatment options have been reported in the literature, and among these is the use of cortical structural homologous bone grafts, which has become an attractive method in selected cases^(3,13,16).

This type of graft can act as a biological plate, either separately or in adjuvant form together with other internal fixation methods. Since the elastic modulus of cortical structural homologous grafts is similar to that of the host bone, there is less mechanical stress than in other, more rigid forms of fixation^(3,22).

In biomechanical studies, Wilson *et al*⁽²³⁾ compared the bone stress in different types of fixation for femoral periprosthetic fractures. They concluded that the structural homologous graft technique was an excellent option, since it improved the stability of the fracture fixation and increased the bone stock.

Chandler⁽²⁴⁾ and Chandler *et al*⁽²⁵⁾ presented the results from using structural homologous bone grafts for treating periprosthetic fractures of the femur, with a mean follow-up of 28 months. Out of 19 cases of periprosthetic fractures that were treated by means of open reduction and internal fixation, with cortical structural homologous bone grafts and cerclage, 16 cases (84.2%) achieved union, with an excellent functional assessment.

Barden *et al*⁽¹⁶⁾ evaluated 19 patients with periprosthetic fractures and significant bone loss that were treated with structural homologous bone grafts, with a mean follow-up of 3.7 years. Consolidation occurred in all the cases, with an increase in the femoral bone stock.

Haddad *et al*⁽³⁾ stated that radiographic signs of bone consolidation following cortical structural homologous grafting are commonly seen within the first postoperative year. In a series of 40 patients with periprosthetic fractures, 39 cases (98%) presented radiographic signs of consolidation within the first year. The change to the bone stock was also assessed by means of radio-

graphic analysis on the cortical index, which presented an improvement.

The consolidation of cortical structural homologous grafts was studied by Emerson *et al*⁽¹³⁾ in femoral revisions of total hip arthroplasty with loss of bone stock. A consolidation rate of 96.6% was observed over a mean period of 8.4 months, starting with partial bridges and followed by complete bridges and remodeling of the femur and the graft.

Callaghan *et al*⁽²¹⁾ evaluated 92 patients who underwent femoral revision of total hip arthroplasty using structural homologous bone grafts, in a series with a mean follow-up of 3.6 years. They compared the bone quality on radiographs produced before the operation and at a late postoperative time, and classified it as good in 60% of the cases.

The minimum follow-up of one year was chosen as an inclusion criterion because of observations in the literature that the radiographic signs of consolidation of cortical structural grafts generally occur during the first year after the operation.

One of the limitations of the present study was the limited number of patients included in the analysis. Another is the possible heterogeneity of the groups of patients who underwent femoral reconstruction following either failure of arthroplasty or periprosthetic fracturing. It was observed that the bone stock increased in 90.5% of the cases and that the femoral bone quality was classified as good in 66.7% of the cases. These data, together with the satisfactory clinical findings among the patients, corroborate the results in the literature, i.e. that the use of cortical structural homologous grafts is an important method in the therapeutic arsenal for femoral reconstructions with great loss of bone stock, and as a coadjuvant in treatments for periprosthetic fractures.

CONCLUSION

The use of cortical structural homologous bone grafts in femoral reconstruction surgery on total hip arthroplasty and periprosthetic fractures is a good treatment option for selected cases and enables satisfactory clinical and radiographic results.

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